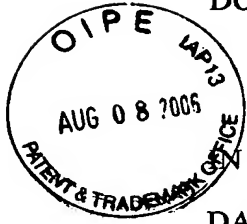


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IN THE UNITED STATES PATENT & TRADEMARK OFFICE



IN RE APPLICATION OF :

DANIEL J TWITCHEN, ET AL.

: EXAMINER: HENDRICKSON, S. L.

SERIAL NO: 10/655,581 :

FILED: SEPTEMBER 5, 2003

: GROUP ART UNIT: 1754

FOR: COLOURED DIAMOND :

DECLARATION UNDER 37 CFR 1.132

I, Geoffrey Alan Scarsbrook of 40 Cavendish Mead, Sunninghill, Ascot, SL5 9TD, Berkshire, United Kingdom, hereby declare that I am an original, first and joint inventor of the subject matter of US application 10/655,581 entitled "Coloured Diamond" (hereinafter the present specification).

I have reviewed the Office Action dated March 20, 2006, and in particular the Examiner's rejection of claims 1-30, 37-40, under 35 U.S.C. 102(b) as being anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Tsuji et al (5,328,548).

I was advised that a personal interview was conducted with the Examiner in charge of this application and have subsequently been advised to submit a declaration that would explain why the presently-claimed invention is different from, and not suggested by, the above applied prior art reference. I was advised further that the Examiner prefers an evaluation of the properties of a diamond actually made by the method disclosed in Tsuji et al in order to overcome the rejection. However, Tsuji et al uses a high pressure synthesis apparatus, whereas the applicants' apparatus is a CVD apparatus. The cost of high pressure apparatus varies considerably with the type used, and Tsuji et al does not make such details clear, but investment costs for high pressure apparatus can exceed \$2M. Access to existing equipment sufficient to reproduce the work of Tsuji et al would typically cost in excess of \$100,000. Thus the applicants are not able to reproduce the work of Tsuji et al. However, I do not

believe that reproduction of the work of Tsuji *et al* is either necessary or relevant to the issue at hand. I am sufficiently familiar with HPHT synthesis of diamond, and more particularly the defects in the diamond resulting from HPHT synthesis, to be able to make the present declaration on the matter.

In view thereof, I describe in this declaration coloured diamond in general and then against this general description compare the present specification and the art prior to this application, in particular the prior art raised by the Examiner.

Background Science

- (1) The colour of a diamond, which results from its absorption in the visible spectrum, is not dependent on the diamond lattice per se, which is a theoretical structure, but on the specific defects within it.

The similarity between the different types of diamond, natural and synthetic diamond, where synthetic diamond may be CVD diamond or HPHT diamond, is that they are all based on the theoretically perfect diamond lattice. The optical properties that would be exhibited by this theoretically perfect lattice are well understood. Specifically, there would be no significant absorption in the visible spectrum so there would be no colour. Accordingly, the colour of a diamond, which results from its absorption in the visible spectrum, is dependent on the specific defects within it.

- (2) The defects controlling the colour in HPHT diamond are *not* the same as the defects controlling the colour in CVD diamond.

The absorption in the optical spectrum observed in natural and synthetic diamond, which gives rise to the visible colours, is dependent on the specific defects present in that particular type of diamond. The behaviour of those defects, in terms of effect on the absorption properties of the diamond, can only be expected to be similar if the defects themselves are identical. However, it is of critical importance to appreciate that this is not the case and that in particular the defects in HPHT diamond are not

the same as those in CVD diamond. CVD diamond contains many defects unique to the process of CVD, and it is these defects which dominate the colour of the material in the present invention.

There are some defects in common, in particular single substitutional nitrogen can be present in both CVD and HPHT material, but in CVD material such as that of the present invention the concentration of neutral single substitutional nitrogen (ssN) is typically < 1 ppm. At this level the single substitutional nitrogen defect adds nothing to the colour visible by eye and provides only a weak characteristic absorption in the UV part of the spectrum where the eye is not sensitive. In contrast ssN levels in coloured HPHT diamond are typically > 10 ppm and more typically > 100 ppm, which broadens the absorption peak at 270 nm and gives the material a very characteristic yellow or brown colour.

Brown CVD diamond is synthesised in a CVD process (typically temperatures of 800°C , pressures of 0.02 MPa, and timescales of hrs), very different to the typical conditions of HPHT, and is generally observed in diamond grown in the presence of nitrogen. The concentration of ssN is too low in concentration to account for the colour, and the colour is thus related to other defects which form in the unique CVD diamond growth process. These defects are therefore unique to CVD, for example adding to the absorption spectrum broad peaks at 350 nm and 500 nm, which are not found in HPHT coloured diamond.

Further confirmation for the difference between the colour centres in CVD of the present specification and HPHT diamond can be found in the annealing behaviour. The colour in the CVD diamond can be modified by annealing at ambient pressure and 1200°C . The colour in HPHT diamond can only be modified by annealing under HPHT conditions and typically at temperatures $> 1800^{\circ}\text{C}$, and results from aggregation of the nitrogen, a mechanism peculiar to the high concentrations of ssN in HPHT.

Reviewing Claim 1

As recited in claim 1, the present invention is a diamond layer of single crystal CVD diamond which is colored and which has a thickness greater than 1 mm.

In view of the above discussion, it is clear that this claim provides some very important distinctions, most notably that the layer of single crystal diamond is CVD diamond and has a thickness greater than 1 mm.

The Prior Art Raised

Tsuji *et al* (5,328,548)

Tsuji *et al* discloses a method of synthesizing single diamond crystals of high thermal conductivity which involves graphitizing amorphous carbon containing at least 99.9 atomic percent of carbon with mass number 12 at a minimum of 1800°C in an inert atmosphere and submitting the thus-obtained highly crystalline carbon to a high pressure and temperature process (HPHT) to process synthetic single diamond crystals, which diamond crystals are described as having a thermal conductivity at least 1.5 times higher than those of conventional synthetic single diamond crystals and are made up of substantially nitrogen-free, natural type IIa diamond (column 2, lines 47-61). As the inert gas, Tsuji *et al* discloses argon gas as the most preferable inert gas, although nitrogen gas may be used instead (column 4, lines 23-25). Tsuji *et al* discloses further that single diamond crystals obtained by the conventional methods of synthesis usually contain 10-100 ppm of nitrogen as an impurity, but that a further improvement in thermal conductivity can be achieved if the nitrogen impurity is completely eliminated (column 4, lines 59-67). In Example 1 therein, Tsuji *et al* discloses the formation of a yellow single crystal that was free from metal inclusions and irregular shape crystals and that contained approximately 60 ppm of nitrogen, which single diamond crystal was cut to a rectangular parallelepiped of 2 x 2 x 3 mm (column 5, lines 46-51).

The most significant difference between the presently-claimed invention and Tsuji et al is that the presently-claimed invention is drawn to single crystal CVD diamond, while Tsuji et al is drawn to HPHT diamond. That the products formed from such processes would necessarily be different from each other would be clearly recognized by persons of ordinary skill in this art, particularly in view of the above discussion. Thus, the presently-claimed invention distinguishes Tsuji et al on this basis alone. In addition, Tsuji et al's description of a yellow single crystal is accompanied with a relatively significant amount of nitrogen, i.e., 60 ppm, as discussed above with regard to Example 1 of Tsuji et al. As mentioned previously, nitrogen incorporation in HPHT diamond is well known, generally taking the form of single substitutional nitrogen (ssN), which gives rise to a yellow color, becoming more brown as the concentration increases. The description of 60 ppm nitrogen is consistent with a yellow color in HPHT diamond. In the present invention, on the other hand, while nitrogen incorporation in CVD diamond does occur, typical levels of nitrogen in the CVD diamond are much lower than 60 ppm, and often substantially lower than 1 ppm. In the CVD diamond of the present invention, significant color is not achieved by the presence of nitrogen in the lattice after synthesis, but rather by the interaction of the nitrogen with the growth process, which creates defects other than ssN, and in many cases, defects which do not contain nitrogen at all. The formation of these defects is very specific to the general method of CVD growth, such as the presently-claimed method herein. Moreover, the yellow color of ssN in HPHT diamond generally gives rise to a hue angle much greater than 90°, such as about 110-120°, and is thus quite distinct from colors obtainable with the present invention, where the hue angles are generally less than 80°. The differences in hue angle provide further evidence of a distinction between CVD diamond of the present invention and the HPHT diamond of Tsuji et al. Thus, the properties of the defects formed in CVD diamond by using controlled nitrogen addition, as in the present invention, are substantially different from the defects in HPHT diamond, thus enabling the unique control of color in CVD diamond, one of the benefits of the present invention. By being able to control the CVD growth process, thereby controlling specific defects, we are able to provide uniquely novel colors in a CVD diamond, which controlled production of colors has never been achieved previously in CVD diamond. Indeed, the HPHT process of Tsuji et al cannot provide such colored diamond of the present invention.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed at *Ascot* this *2nd* day of *August* 2006



GEOFFREY ALAN SCARSBROOK